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ABSTRACT

This study examined the effects of animated presentations on intentional and incidental learning and the degree to which computer practice activities contained intrinsically motivating characteristics as measured by continuing motivation. A total of 70 fourth graders participated in an introductory lesson on Newton's laws of motion. Two levels of visual presentation (static graphic and animated graphic) were crossed with two levels of practice order (questions/simulation and simulation/questions). Within-subject factors consisted of learning intent (intentional or incidental), visual testing format (all verbal or verbal and visual), and test interval (immediate or delayed). Results showed that animated graphics successfully promoted incidental learning. In addition, students overwhelmingly chose to return to the structured simulation practice when placed in a free-choice situation. (33 references) (Author/GL)

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Effects of Animated Visuals on Incidental Learning and Motivation

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Abstract

The effects of animated presentations on intentional and incidental learning was studied. Also studied was the degree to which computer practice activities contained intrinsically motivating characteristics as measured by continuing motivation. A total of 70 fourth graders participated in an introductory lesson on Newton's Laws of Motion. Two levels of Visual Presentation (Static Graphic, Animated Graphic) were crossed with two levels of Practice Order (Questions/Simulation, Simulation/Questions). Within-subjects factors consisted of Learning Intent (Intentional, Incidental), Visual Testing Format (All Verbal, Verbal/Visual), and Test Interval (Immediate, Delayed). Results showed that Animated Graphics successfully promoted incidental learning. In addition, students overwhelmingly chose to return to the structured simulation practice when placed in a free-choice situation.

Recent advances in authoring computer-based instruction (CBI) have provided designers with relatively easy means of adding diverse and elaborative features to instructional software. Features which once demanded advanced programming skills and liberal development timelines can now be almost casually incorporated. Animation has long been a popular feature in CBI, and its use, along with other types of graphics, is often encouraged (Bork, 1981; Caldwell, 1980). Unfortunately, animation is frequently added to CBI without serious concern for its true instructional purpose or impact.

Instructional research has focused on two fundamental applications of animation in CBI: 1) animation as a presentation strategy; and 2) practice activities involving interactive animated graphics. Recent reports have offered encouraging results for both applications (Rieber, in press-b; Rieber, Boyce, & Assad, in press). General theoretical support of animated visuals is provided by the dual-coding hypothesis (Paivio, 1986) which suggests that highly visual, concrete information is stored both verbally and visually. Retention can be enhanced by external pictures if they promote the activation of dual-coding. When information is dual-coded, the probability of retrieval is increased since if one memory trace is lost, another is still available (Kobayashi, 1986). Efficacy of animated presentations appears particularly dependent on task requirements, cognitive load, and attention-gaining devices. In addition to gains on intentional learning, Rieber (in press-b) reported initial evidence of animation's role in contributing to incidental learning. Elementary school students demonstrated modest success in attending to incidental information contained in a single animated display. A need exists to validate this preliminary finding and investigate its implications further.

The study of incidental learning is well established (Ackerman, 1985; Goldberg, 1974; Klauer, 1984; Lane, 1980; Sagaria & Di Vesta, 1978). Past research has primarily focused on interactions between text processing activities, such as pre- and post-questions, and intentional and incidental learning. The search for true "mathemagenic" activities, or activities which give "birth" to learning in general (Rothkopf, 1966), has led researchers to understand that most instructional activities incur tradeoffs between intentional and incidental learning — contributions to one generally impede the other. Most of this research has concentrated on learning from prose, although several imagery studies have been reported which indicate that recall of incidental information is more robust for pictures than for words (Ghatala & Levin, 1981). Traditional CBI design, based on systems approaches (see Reigeluth, 1983 for a review), has only been concerned with intentional learning, that is, the extent to which predetermined learning objectives have been mastered. Unfortunately, this approach can also

lead to instructional designs which are unnecessarily self-limiting and restricting and which are apt to assign a passive role to the learner. The ability of the learner to elaborate upon instruction as well as induce rules and principles not intentionally taught is usually overlooked or ignored. The first objective of this study was to investigate whether students would be able attend to incidental information contained in animated visuals and induce a resulting physical science principle from this information without sacrificing intentional learning.

Previous research has demonstrated that animated presentations interact with the practice activities provided in CBI. Traditional CBI has used questioning strategies as successful practice activities (eg. Hannafin, Phillips, & Tripp, 1986). Rieber (in press-b) and Rieber, Boyce, and Assad (in press) compared the effects of questioning strategies to structured simulations as practice activities in science instruction. The structured simulations consisted of animated graphics which obeyed the laws of motion and were under student control. Brown (1983) has termed these applications of animated graphics as "interactive dynamics". The graphics change continuously over time depending on student input, thus acting as a form of instantaneous feedback (Reed, 1985). Adult performance compared equally with both forms of practice, while elementary school children performed best given the experiences with the interactive dynamics. It is speculated that the success of the interactive dynamics with children was due in part to the apparent intrinsic motivational appeal of the simulation — students were encouraged to fantasize about being the pilot of a starship in outerspace. Intrinsically motivating instruction relies on student-driven strategies, rather than external lesson reinforcement (Lepper, 1985; Malone, 1981). Theories concerning intrinsically motivating instruction are based on motivation research which suggests that students who see themselves in control of their success are destined to stay-on task longer in more meaningful ways and are more likely to return to the instructional task given the freedom to choose (Malone, 1981; Rotter, 1954; Weiner, 1979). The second objective of this study was to validate whether or not these structured computer simulations hold intrinsically motivating characteristics for children. Measures of continuing motivation, such as choosing to return to an instructional task in a free-choice situation, have been used successfully to estimate the construct of intrinsic motivation (eg. Kinzie & Sullivan, 1989). Continuing motivation can be defined as an individual's willingness to return to an activity once external pressure to do so has ceased (Maehr, 1976).

There were two purposes to this study: 1) to investigate the effects of computer animated presentations on intentional and incidental learning; 2) to investigate the locus of motivation to participate in computer-based practice activities. It was hypothesized that students given lessons containing animated presentations would significantly outperform other students on measures of incidental learning. It was also hypothesized that students would choose to return to practice activities involving interactive dynamics more often than other computer practice activities or even other high-interest, non-lesson activities, such as paper puzzles.

Methods

Subjects

The subjects consisted of 70 fourth grade students from an urban public elementary school. Participation was voluntary with selection based on parent consent.

CBI Lesson Content

The CBI lesson, first developed for previous studies (Rieber, in press-a, in press-b; Rieber & Hannafin, 1988) but modified for this study, described and explained Newton's laws of motion. The lesson was divided into two parts. Part one introduced students to Isaac Newton and his first law of motion. Part two provided applications of Newton's first law and an initial application of Newton's second law where mass is held constant and forces vary. All information was presented at an introductory level in the context of one-dimensional motion.

Lesson Versions

Two levels of Visual Presentation (Static Graphic, Animated Graphic) were crossed with two levels of Practice Order (Questions/Simulation, Simulation/Questions).

Visual Presentation. In each Visual Presentation condition the lesson narrative was supplemented with either static or animated graphics. In the Static Graphics condition, forces were represented by a foot giving an object a kick, such as a ball or a concrete block.

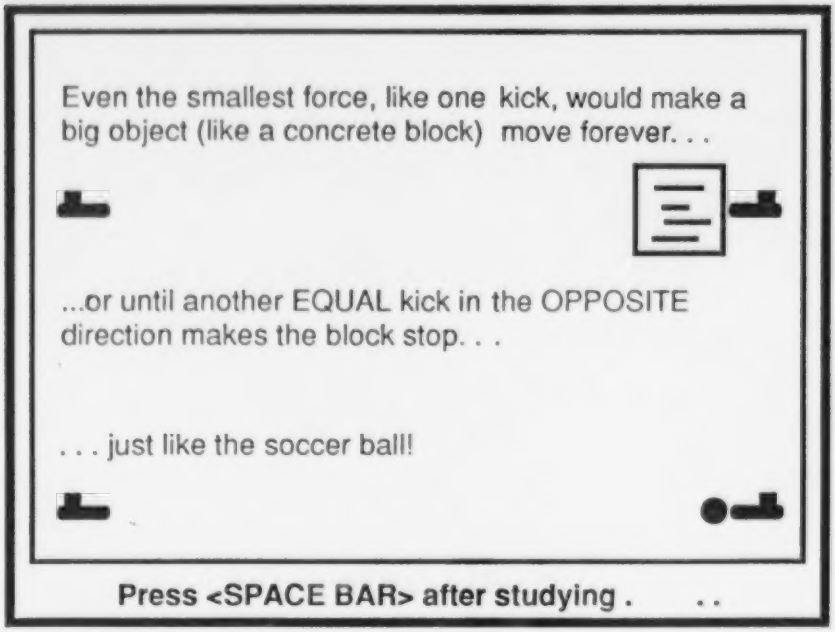
Even the smallest force, like one kick, would make a big object (like a concrete block) move forever. . .
...or until another EQUAL kick in the OPPOSITE direction makes the block stop. . .
. . . just like the soccer ball!
Press <SPACE BAR> after studying . . .

FIGURE 1. *Example of a computer screen which used animation to present intentional and incidental information. The "concrete block" and the "ball" were both kicked once. The animation depicted the ball's speed as dramatically greater than that of the block.*

Motion and trajectory attributes were represented by arrows and path lines. The Animated Graphics condition also used the ball, block and foot symbols, however the object was then animated to show the motion and trajectory resulting from the force applied to it. Both types of visuals elaborated the textual information. However, another application of Newton's second law was incidentally demonstrated in the Animated Graphics condition. This law predicts that when two objects of different masses are both acted on by the same size force, the acceleration experienced by the object with larger mass is less. The computer animated a large solid box moving very slowly across the computer screen after being kicked with the same size force which had just been applied to a small animated ball, similar to what is illustrated in Figure 1. No attempt was made to teach or explain why the box moved more slowly than the ball.

Practice Order. Each level of Practice Order consisted of giving all students two types of practice activities, but in different order. The first practice activity consisted of multiple-choice questions. The questions covered the relevant material in the respective lesson part. Feedback was provided to the students in the form of knowledge of correct results. The second practice activity involved the student in a structured simulation. Students were given increasing levels of control over a simulated, free-floating object called a "starship" in the lesson. This structured simulation, an application of the dynaturtle microworld developed by diSessa (1982) and White (1984), had been shown to positively affect lesson performance in prior research with children of this age (Rieber, in press-b). Students participated in the practice activities in the respective order (Questions/Simulation or Simulation/Questions) after each of the two lesson parts. It was important that all students have equal opportunities to experience both forms of practice so that interpretation of the free-choice data would be valid. However, it was anticipated that the first activity might orient students to the second activity, thus resulting in different success patterns for each activity. This could affect the motivating appeal for each activity. Therefore, Practice Order was added to the experimental design to prevent this from confounding the study. It was not the intention of this experiment to study the performance effects of each practice activity, as this has been adequately demonstrated elsewhere (e.g. Rieber, in press-b).

Dependent Measures

Posttest. The 24-item posttest measured two types of rule learning: intentional and incidental. Intentional learning is defined as learning those objectives which were directly taught in the lesson through the combination of verbal (text) and visual means. Incidental learning is defined as learning those objectives which were not directly taught, but only implied through contextual cues provided in several of the animated visual displays. The posttest was administered twice: first, in two parts immediately upon completion of the relevant lesson parts, and then again approximately two days later in whole as a measure of learning decay/ durability. The use of visuals in the testing was also controlled. Half of the intentional and incidental questions were presented in an all-verbal form and half contained accompanying visuals. Two questions were added to the final administration of the posttest which tested a simple application of Newton's Law of Gravitation. This objective was not taught in any form during the lesson. However, it was anticipated that the animated visuals might promote the misconception that two objects of different masses would fall at different speeds when dropped to the earth. These two questions provided a preliminary measurement of whether such a misconception was actually formed by students.

KR-20 reliability of all 50 questions was .93. Respective reliability coefficients and number of questions for each of the subscales were as follows: .87, 24 (Immediate); .87, 24 (Delayed); .91, 28 (Intentional); .95, 20 (Incidental); .91, 26 (Verbal); .85, 22 (Visual); .64, 2 (Law of Gravitation).

Response Latency. The time required by students to process each of the posttest questions was collected. Processing time is measured as the time (in seconds) taken by students to press the appropriate key once prompted to do so. This variable provides an important indirect measure of the organization strength of initial encoding as evidenced by retrieval time.

Continuing Motivation. Immediately after completing the second administration of the posttest on the fourth day, students were given three choices: 1) answer more practice questions just for fun; 2) spend more time in the structured simulation; or 3) complete a word-find puzzle on another topic. Students were told that they could switch between activities if they wished to do so. Continuing motivation of the practice activities was measured by first choice frequencies of these two options as compared to the first choice frequency of the puzzle activity.

Procedures

All instruction and testing was administered by computer over the span of four, 30 minute computer sessions. The first session acted as a general orientation to familiarize students to the materials and nature of the project. The second session presented lesson part one, followed by practice and then 12 posttest questions relevant to that part. The third session presented lesson part two, followed by practice and then 12 posttest questions relevant to part two. The fourth session involved a re-administration of the original 24 posttest questions and 2 additional questions which measured Newton's law of gravitation. As already indicated, these two questions were added as a preliminary measure of whether the animated graphics promoted misconceptions. After the posttest, students were given the choice to work on either of the two computer-based practice activities (questions or simulation) or an irrelevant, though highly motivating activity consisting of a word-find puzzle. Each session lasted approximately 30 minutes amounting to about 120 minutes of learner time over the course of about 10 days. Students were randomly assigned to one of the treatment groups as they arrived at the computer lab for the first session. Once instructed to begin at the start of each session, students completed the lesson individually under controlled conditions.

Design

In this study a 2 X 2 X (2 X 2 X 2) factorial design was used. Two between-subjects factors levels (Visual Presentation, Practice Order) were crossed with three within-subjects factors (Learning Intent, Visual Testing Format, Test Time). The between-subjects factors consisted of two levels of Visual Presentation (Static Graphic, Animated Graphic) and two levels of Practice Order (Questions/Simulation, Simulation/ Questions). The within-subjects factors consisted of two levels of Learning Intent (Intentional, Incidental), two levels of Visual Testing Format (All Verbal, Verbal/Visual), and two levels of Test Time (Immediate, Delayed). A mixed factor analysis of variance (ANOVA) was used to analyze the quantitative data. The within-subjects factors also served as dependent

TABLE 1. *Mean Percent Scores and Standard Deviations for the Posttest*

			Immediate Posttest			
			Intentional		Incidental	
Visual Presentation	Practice Order		Verbal	Verbal/ Visual	Verbal	Verbal/ Visual
Animated Graphic	Questions/ Simulation	Mean	73.5	69.9	66.4	76.5
		SD	(30.7)	(27.3)	(29.4)	(28.3)
		n	17	17	17	17
	Simulation/ Questions	Mean	75.5	69.1	59.7	76.5
		SD	(24.4)	(26.2)	(32.0)	(36.8)
		n	17	17	17	17
Static Graphic	Questions/ Simulation	Mean	61.8	53.7	15.1	29.4
		SD	(21.9)	(27.2)	(13.8)	(28.6)
		n	17	17	17	17
	Simulation/ Questions	Mean	66.7	52.6	15.0	22.8
		SD	(35.1)	(31.6)	(25.0)	(31.5)
		n	19	19	19	19

			Delayed Posttest			
			Intentional		Incidental	
Visual Presentation	Practice Order		Verbal	Verbal/ Visual	Verbal	Verbal/ Visual
Animated Graphic	Questions/ Simulation	Mean	74.5	81.6	69.7	70.6
		SD	(28.3)	(18.8)	(27.6)	(37.0)
		n	17	17	17	17
	Simulation/ Questions	Mean	68.6	79.4	65.5	66.7
		SD	(25.6)	(18.2)	(27.7)	(37.3)
		n	17	17	17	17
Static Graphic	Questions/ Simulation	Mean	52.9	59.6	16.0	17.6
		SD	(21.4)	(28.5)	(23.6)	(33.6)
		n	17	17	17	17
	Simulation/ Questions	Mean	54.4	59.2	10.5	15.8
		SD	(37.6)	(32.8)	(24.2)	(28.0)
		n	19	19	19	19

Notes: SD-standard deviation; n-number of subjects

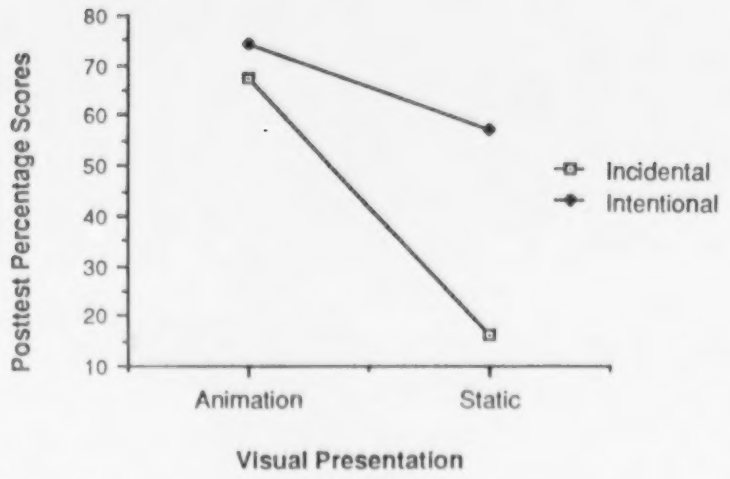

FIGURE 2. *Interaction between Visual Presentation and Learning Intent.*

measures. A Chi Square analysis was used to test students' first choice preferences of each post-lesson activity as a measure of continuing motivation of the practice questions and the simulation.

In addition, separate analyses were conducted on the questions measuring misconceptions of Newton's law of gravitation and the response latency data from the posttest.

Results and Discussion

Posttest

Percent means and standard deviations of student posttest scores are contained in Table 1. An a priori decision was made to ignore interactions involving three or more factors. A significant main effect was found for Visual Presentation, $F(1,66)=60.17$, $p=.001$, $MS_{error}=2649.37$. However, interpretation of this effect must be qualified because of its interaction with Learning Intent, $F(1,66)=18.73$, $p=.0001$, $MS_{error}=2249.61$. Figure 2 illustrates the nature of this interaction. Students in the Animated Graphics group performed similarly on both intentional (mean=74.2%) and incidental questions (mean=67.5%), whereas students in the Static Graphics group performed significantly better on intentional learning questions (mean=57.4%) than incidental questions (mean=16.3%). As expected, these latter students performed at about the guessing level on incidental questions. This result supports the first hypothesis of this study that students receiving animated demonstrations of incidental information would attend, understand, and retrieve this information when tested although no formal attempt was made to teach or explain the principle. The superiority of the Animated Graphics group over the Static Graphics group on intentional learning is consistent with previous research (Rieber, in press-b).

Among the within-subjects factors, significant main effects were found for Learning Intent, $F(1,66)=31.28$, $p=.0001$, $MS_{error}=2249.61$, and Visual Testing Format, $F(1,66)=5.39$, $p=.02$, $MS_{error}=306.59$. Not surprisingly, students scored higher on questions measuring Intentional Learning (mean=65.6%) than questions measuring Incidental Learning (mean=41.1%). Students scored higher on questions containing either a static or animated visual (mean=60.1%) than questions containing no visual (mean=51.4%). However, a significant interaction was found between these two factors, $F(1,66)=5.62$, $p=.02$, $MS_{error}=357.52$. Students tended to answer Incidental Learning questions which contained visuals more accurately than questions which contained no visuals. Student scores on questions measuring Intentional Learning did not vary significantly depending on the use of visuals in the questions. This implies that in this study, the use of visuals in the test construction did not measure differentiated amounts of intentional rule learning. However, test questions which included visuals did vary in their measurement of incidental rule learning.

Response Latency

A main effect was found for Test Time, $F(1,66)=46.13$, $p=.0001$, $MS_{error}=35.99$. Students took significantly less time to answer the posttest questions during the second administration of the posttest. Retrieval time would be expected to decrease during retesting, especially when the second administration occurred within 48 hours, as was the case in this study. However, an ordinal interaction was found between Test Time and Visual Presentation, $F(1,66)=5.48$, $p=.02$, $MS_{error}=35.99$. Students in the Statics Graphics group varied less in response time from the first and second administration of the posttest than students in the Animated Graphics group. This interaction is probably an artifact of the rate of guessing on incidental questions by the Static Graphics group.

A main effect was found for Learning Intent, $F(1,66)=80.89$, $p=.0001$, $MS_{error}=30.80$. Students took significantly less time to answer questions measuring Intentional Learning than questions measuring Incidental Learning. However, an ordinal interaction was also detected between Learning Intent and Visual Presentation, $F(1,66)=8.77$, $p=.004$, $MS_{error}=30.80$. Students in the Animated Graphics group took significantly longer to answer questions measuring Incidental Learning than students in the Static Graphics group. This was expected. Students in both Visual Presentation groups were required to overtly process incidental information for the first time during the posttest. Since students in the Static Graphics group had to revert to either guessing or personal experience, their latency rates for these questions would be expected to be lower than for students in the Animated Graphics group. These latter students were asked to answer questions pertaining to information which was only incidentally represented in the animated visuals. If students encoded the incidental information significant time would be necessary to retrieve this information and formulate a rule which could be used to answer the question. There was no difference in response time between Animated Graphics and Static Graphics groups for Intentional Learning.

A main effect was found for Visual Testing Format, $F(1,66)=126.97$, $p=.0001$, $MS_{error}=31.15$. Overall, students took much less time to respond to questions which contained either static or animated visuals than questions which contained no visual supplements. This too was expected. All of the information and testing was highly visual in nature. Questions which did not provide external visuals would require students to form their own internal or external (eg. doodles on paper) images in order to solve the problems. When visuals were provided with the questions, students could by-pass this time-consuming cognitive step, assuming that the visual was congruent with each student's mental schema. It is insightful to compare the latency and performance results for this factor. Even though the addition of external visuals to questions which measured intentional learning did not contribute to performance differences, the decrease in latency suggests that these visuals nonetheless aided the cognitive processing necessary for accurate responses.

Continuing Motivation

Respective first choice frequencies for each of the three post-lesson activities were as follows (the first number indicates the raw frequency and the second number indicates percentage of total first choices): Questions, 3, 4.3%; Simulation, 42, 60.0%; Puzzle, 25, 35.7%. For the purposes of the Chi Square analysis, answering more practice questions acted as a non-choice and was removed from the analysis. Overall, students first chose to participate in the structured simulation more often than either the puzzle activity or the practice questions, Chi Square=3.88, $p<.05$, $df=1$. This result supports the second hypothesis of the study which contended that the practice provided by the structured "starship" practice held intrinsically motivating appeal for the students. It is contended that this appeal would lead students to *choose* to stay on task longer in meaningful ways. This result further clarifies performance effects of this practice activity as reported by Rieber (in press-b).

Student Conceptions of Gravitation

A significant main effect was found for Visual Presentation, $F(1,66)=18.24$, $p=.0001$, $MS_{error}=1044.19$. Students in the Animated Graphics group (mean=5.9%) performed significantly worse on the two questions measuring a simple application of Newton's law of gravitation than students in the Static Graphics group. This suggests that students in the Animated Graphics group were more prone than other students to the misconception that Newton's second law predicts the free fall characteristics

of objects of different masses on earth. This result provides an important counterbalance to the apparent ability of students to attend to animated visuals which incidentally demonstrates a scientific principle. While students may be appropriately attending to the details, they may be drawing a whole series of conclusions — some of which are appropriate, and some of which are not. This phenomena is consistent with previous research on other misconceptions in science where people formulate conceptions of physical phenomena based on daily observable events (see Eylon & Linn, 1988, for a review). Without direct guidance, such as that provided by instruction, students may formulate innumerous and potentially erroneous "theories" about the physical world.

General Discussion

There were two purposes to this study. First, the ability of students to first attend to incidental information contained in an animated visual, and then extract and induce science principles was investigated. The Animated Graphics group was given demonstrations of an extension of Newton's second law where the masses of two objects varied, but the forces acting on them remained constant. However, the fact that these demonstrations represented a distinct extension of this principle was never brought to their attention. In fact, the demonstrations were presented in the context of explaining other lesson content. It is believed that attention to intentional learning alone placed significant cognitive loads on students. Yet, they were able to gain understanding of the incidental information, without apparently sacrificing any intentional learning. The results reported here demonstrate the rather startling ability of fourth grade students to attend to, formulate, and apply even a sophisticated science principle introduced in an incidental fashion.

However, this result is tempered by the alarming number of students who continued to apply this incidental information to other, *inappropriate* contexts. Students in the Animated Graphics condition were much more likely to hold misconceptions about the effects of gravity on objects of different masses. This is not really surprising. The animated demonstrations of Newton's second law occurred in a simulated gravity-free/frictionless environment. The concept and effect of gravity was purposely removed from the discussion. Without additional guidance, it is logical and intuitive to apply Newton's second law to contexts where objects of different masses are freely falling on earth (such an intuitive assumption led Galileo to demonstrate otherwise at the leaning Tower of Pisa).

The second purpose of this study was to estimate the construct of intrinsic motivation as it related to several practice activities shown effective in CBI in previous research — questioning strategies and structured simulations. Understanding whether certain activities have intrinsic motivating appeal is important when designing CBI. If activities contain such appeal for students, they will be more likely to maintain interest and stay on-task for longer periods of time. This is because the focus of the reinforcement is internal — that is, students motivate themselves. This is contrast to traditional CBI, largely based on behavioral designs, where learning is believed to be the result of constant and appropriate *external* reinforcement. It can be argued that internal reinforcers account for most informal daily learning such as that experienced through hobbies and sports. Designers of CBI practice activities have many strategies from which to choose. It is argued here that while several activities may promote similar performance levels, activities which are intrinsically motivating carry other significant advantages such as personal satisfaction, challenge, and relevance and promotion of a positive perspective on lifelong learning (cf. Keller & Suzuki, 1988). Previous research has used student free choice patterns as a measure of continuing motivation (Kinzie & Sullivan, 1989). In this study, students overwhelmingly chose to return to the "starship" practice more often than questioning activities or even traditionally entertaining activities such as word-find puzzles to support the contention that the structured simulation carries intrinsically motivating appeal for students of this age. It is further contended that the activities, and not the computer, possesses these characteristics based on the fact that of the other two choices, the paper and pencil activity was overwhelmingly chosen over the remaining computer activity (questions).

This study has also provided preliminary findings concerning the role of visuals in computer-based testing. Testing learning outcomes which are highly visual in nature poses problems

for researchers. A visual in a test question may actually act as an unintentional learning aid which could confound results. However, the validity of testing visual learning outcomes with solely verbal means can easily be questioned. Insights into this dilemma were hoped to be gained by controlling for visuals in the testing. In this study, the validity of questions measuring intentional learning was not related to the presence of visuals. Questions which did not contain visuals appeared to state the problem in terms which enabled students to form their own appropriate internal images. This was not true when measuring incidental learning. Students apparently had difficulty forming internal images on their own as they attempted to solve the problem. More work is needed to understand the role of visuals in testing (other examples include Hale, Oakey, Shaw, & Burns, 1985; and Taylor, Canelos, Belland, Mayton, & Dwyer, 1989).

Lastly, students in this study did not experience significant learning decay over the two day test-retest interval. Previous studies have indicated that picture effects are durable over long periods of time (Anglin, 1986; Peng & Levin, 1979). The results reported here support this contention.

In conclusion, this study has shown one example of the powerful ability of students to learn in incidental ways. Designers of CBI need to harness this ability by promoting it whenever possible while trying to avoid inappropriate student elaborations. One application of this research to the development of CBI may be to use incidental information as an orienting activity for subsequent intentional instruction. More research is needed to understand how to best incorporate incidental learning benefits into the design of CBI. Additionally, this study has provided strong evidence to suggest that certain computer practice activities contain intrinsically motivating appeal for elementary school students. Future research should be directed at replicating these results in other contexts and content areas.

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